GEER (Glenn Extreme Environments Rig): Current Project Status. Ike Chi[1], Daniel Gerges[1], and Jeff Balcerski[2], [1]NASA Glenn Research Center, 21000 Brookpark Rd., Cleveland, OH 44135 USA (su.c.chi@nasa.gov), [2]Ohio Aerospace Institute, 22800 Cedar Point Rd, Cleveland, OH 44142 USA

Introduction: Venus is Earth's closest planetary neighbor, and it is often considered as Earth's twin for its size and density [1]. However, the extreme Venus surface conditions (temperatures of ~ 460ºC, pressure of ~90 bars, and reactive atmospheric chemical species such as supercritical CO_2, sulfuric acid, and other toxic elements) results in short duration of Venus lander missions to date to survive for only 127 minutes [2]. It is essential to enable multiple longer-lived Venus surface missions to understand the planet's origin, history, climate, and interior. A systematic approach for future Venus lander material selection is to characterize and study the reactivity of high potential materials by exposing materials to a simulated Venus surface conditions. Glenn Extreme Environments Rig (GEER) at NASA's Glenn Research Center (GRC) has been the leading facility simulating the high-temperature and pressure extremes of Venus as well as reproducing conditions of the gas mixture expected at the Venus surface since 2015 [3]. Here, we report on GEER's recent accomplishments in assessing risks for future potential Veuns missions and ongoing testing process and capability enhancement in supporting other planetary science missions.

Accomplishments: In Fiscal Year (FY) 2020-2021, the GEER facility was stalled due to the impact of COVID-19 pandemic. Now, the GEER team has brought the facility back to its normal operation schedule. Below are the highlights of significant accomplishments in FY2022-2023:

1. Juno mission support: First test program post pandemic to enable science driven exploration of water vapor impacts at various Jupiter related conditions on microwave sensing.
2. Weathering test of Rocks and Minerals: Test in which GEER demonstrated a newly added capability of being able to support over 350 passive samples in one test run.
3. High Operating Temperature Technology (HOTTech)-1 test: First test run for the HOTTech Program, kicking off a series of multiple technology maturation tests.
4. HOTTech-2 Year 1 test: Continuation of HOTTech Program, exposure test for more advanced electronics and protective coating materials.

GEER Operation: The goal for GEER operations is high quality and efficient investigations in a cost-effective manner. One part of this is to provide sufficient and accurate calibration and test characteristic information of the GEER facility allowing for timely adaption to the evolving academic and industrial needs. Furthermore, over time GEER customers' expectations for test design have become more complex and while Venus surface-oriented technologies are also maturing to higher TRLs (Technology Readiness Levels). To meet future customers' demands and expectations, the GEER team introduces the soft launch of revised GEER testing processes in FY2024. There are two phases in this revised GEER testing processes. In the Phase I: Test Planning, it is critical for potential customers to fill out the GEER Test Requirements Document (TRD), which will be available through the GEER website [4]. Most GEER potential customers may expect to spend 4 to 8 weeks finalizing the scope of work, cost estimate and test agreement with the GEER team before proceeding to the Phase II: Testing. In the Phase II, test execution depends primarily on the duration at conditions, the complexity of the test setup and the required startup & shut down sequences for safety and data integrity.

Conclusions: GEER at NASA's GRC has been simulating Venus surface conditions to enable scientific understanding of atmospheric and surface interactions, technology development and material compatibility for long-duration Venus surface exploration and future spacecraft missions. Post COVID-19 pandemic, the GEER team has successfully supported NASA's HOTTech Program, Juno Spacecraft Mission, and other scientific experiments [4]. The GEER facility is a critical Planetary Science Community asset, and we are looking forward to continuing contributing the success of the community and support upcoming space exploration missions.

Acknowledgments: This work was performed at NASA's Glenn Research Center (GRC). The work was funded by NASA's Science Mission Directorate's Planetary Science Division. The authors would like to acknowledge Dr. Tibor Kremic, Dr. Gary Hunter, Mr. Nathan Funk, Dr. Sara Port, Mr. Kyle Philips and the entire GEER Project Team for many valuable discussions.

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